

Enabling a Low-Carbon Transition While Fossil Fuels are Still Abundant: The U.S. Dilemma

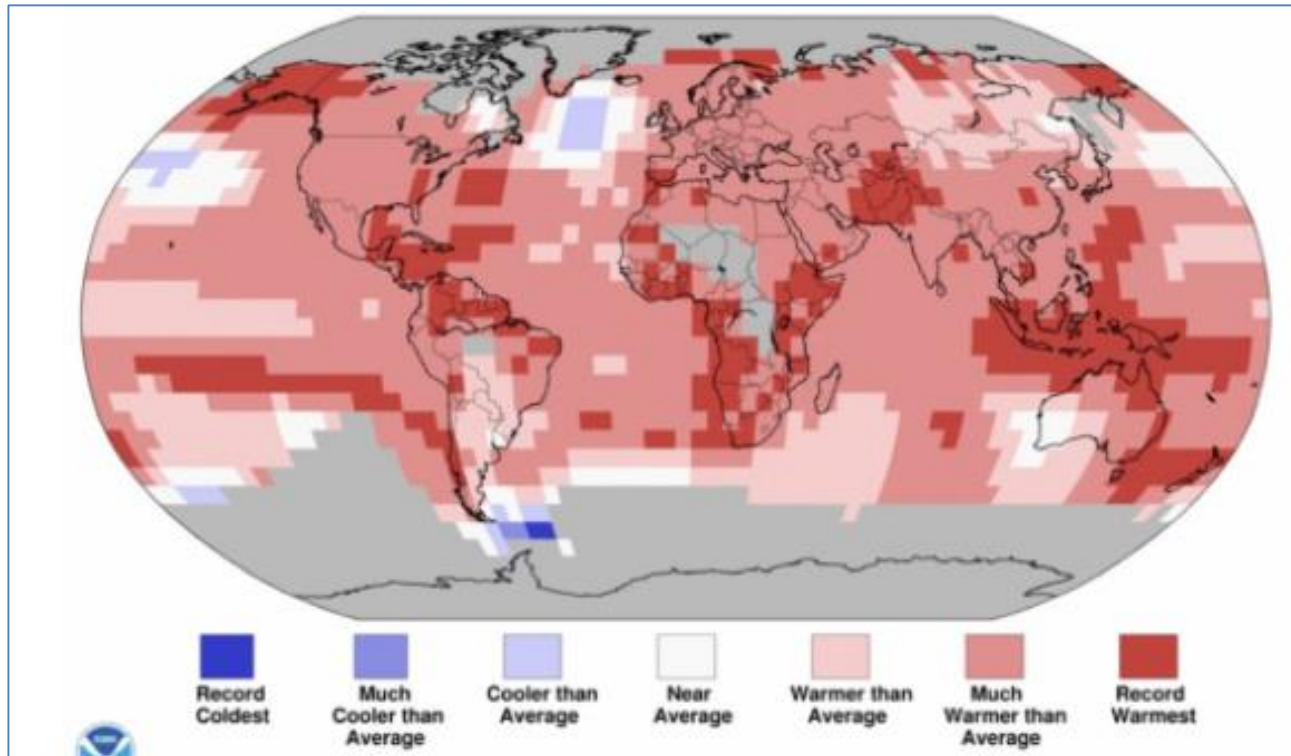
Dr. Marilyn A. Brown

*Regents' & Brook Byers Professor of Sustainable Systems
Georgia Institute of Technology*



Kyushu University: Energy Week 2019
January 29, 2019

2015-18 = Four Hottest Years on Record



2016 temperatures compared to normal around the globe (NOAA)

“...human activities, especially emissions of greenhouse gases, are the dominant cause of the observed warming”

(National Climate Assessment Special Report 2017)

Sea Level Rise: A Global View

- The latest Intergovernmental Panel on Climate Change report estimates a likely rise from 0.28-0.98 m by 2100.
- But melting of the ice sheets in Greenland and Antarctica could result in sea-level rise of 80 meters.
 - Greenland: 6 to 7 m of potential sea level
 - West Antarctica: 6 to 8 m of potential sea level
 - East Antarctic Ice Sheet: 65 to 67 m of potential sea



Sources: Mendelsohn: <https://cepl.gatech.edu/sites/default/files/attachments/robert-mendelsohn-gatech-seminar-2018-11-29.pdf>; Church and Clark, 2013 and <https://pubs.usgs.gov/fs/2005/3055/>

“Will We Survive Climate Change?”

- Fortunately, global warming does not provide enough heat to melt all of the ice sheets suddenly.
- There is time for mitigation and adaptation.

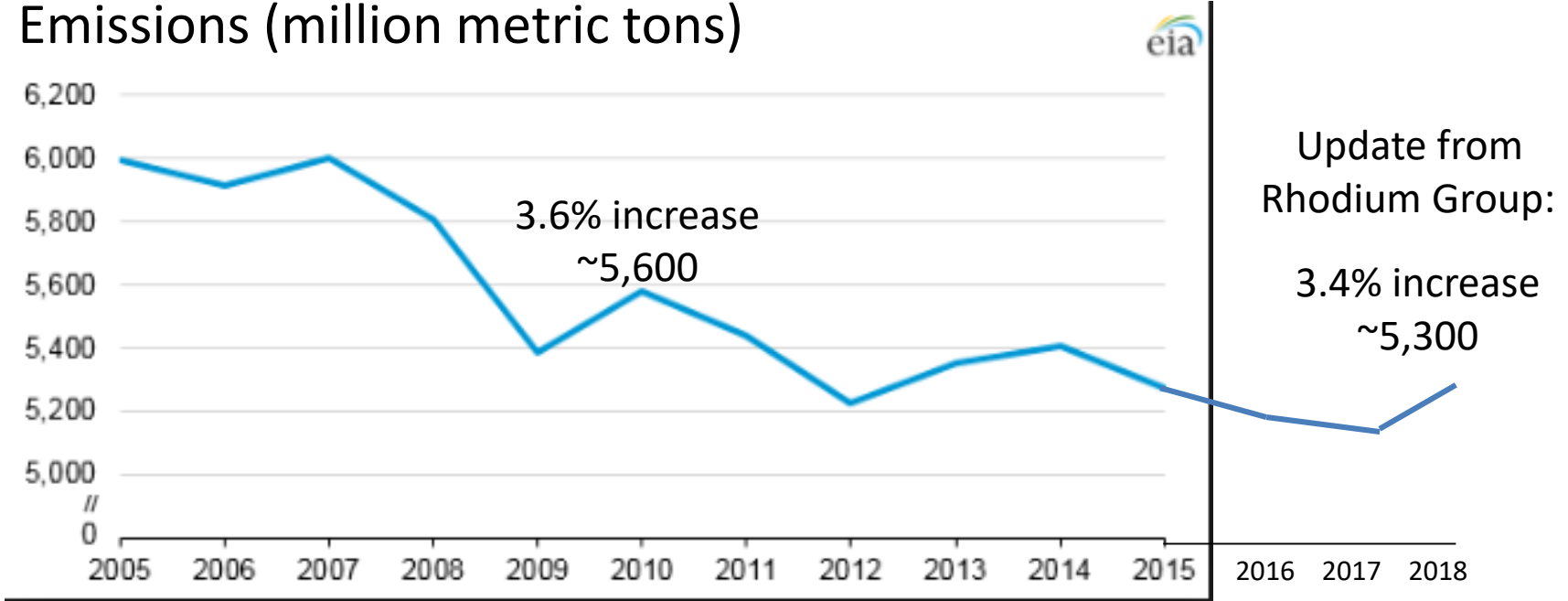


Sources: <http://www.southernfriedscience.com/science-in-the-fleet-what-would-youre-hometown-look-like-with-80-meters-sea-level-rise/#more-15649>

How is the U.S. Responding?

After a 10% decline (2005-2015) in CO₂,
an increase of 3.4% in 2018.

Economy-Wide Energy-Related CO₂
Emissions (million metric tons)



Source for updates: <https://rhg.com/research/preliminary-us-emissions-estimates-for-2018/>

How can the U.S. transition to clean energy when fossil fuels are so abundant and their carbon emissions aren't taxed?

Marilyn Brown
@Marilyn_Brown1

Marilyn A. Brown is a Regents' and Brook Byers Professor of Sustainable Systems in the Georgia Institute of Technology's School of Public Policy.

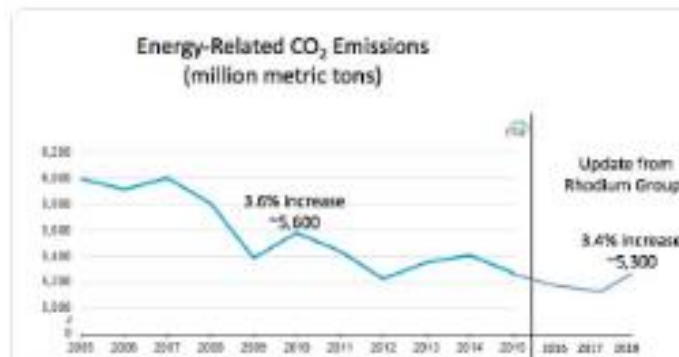
Atlanta, GA
CEPL.gatech.edu
Joined September 2012
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Marilyn Brown @Marilyn_Brown1 · 3m
One more time: CO2 emissions rose by ~3.4% in 2018 after 3 years of decline, due primarily to more natural gas-fired electricity, trucking, and air travel. How can the U.S. transition to clean energy when fossil fuels are so abundant and their carbon emissions aren't taxed?



More natural gas-fired electricity, trucking, and air travel....

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U.S. CO₂ Emissions are Far Off Track for Global Climate Goals

Annual Energy Outlook 2019
with projections to 2050

- Fossil fuel reliance persists.
- You won't find this graph here.

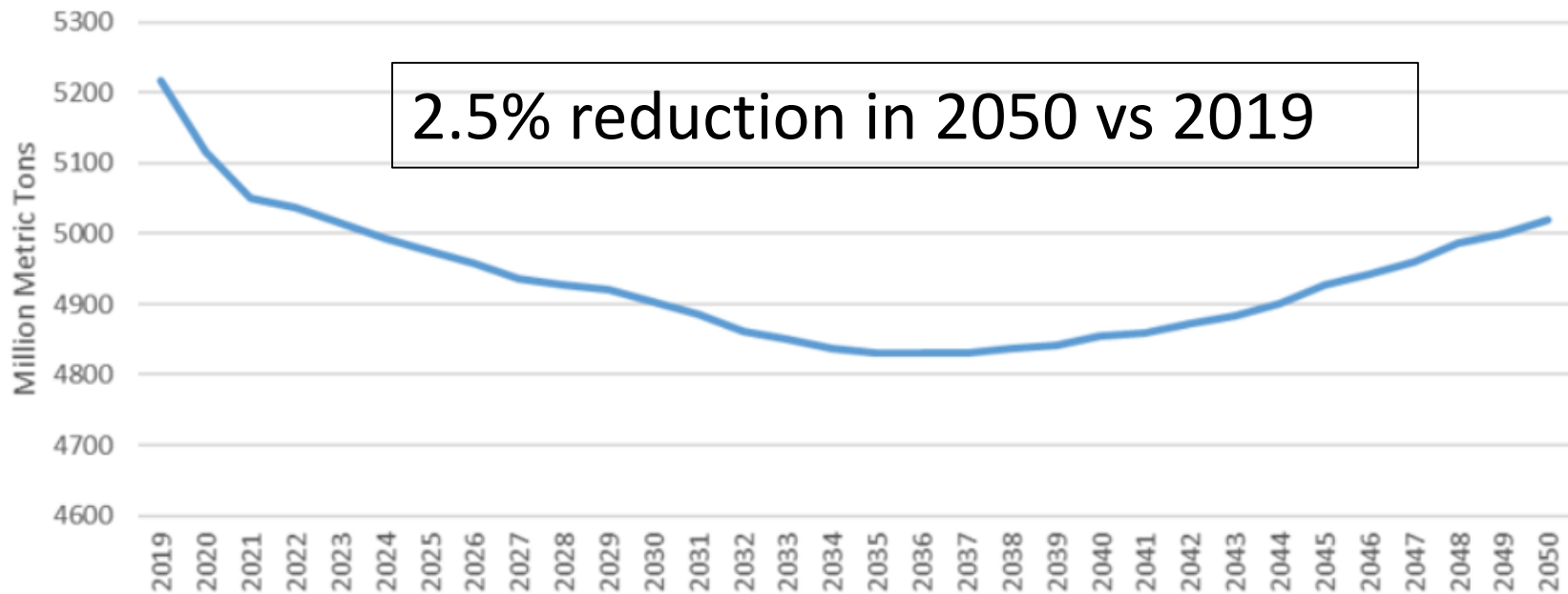


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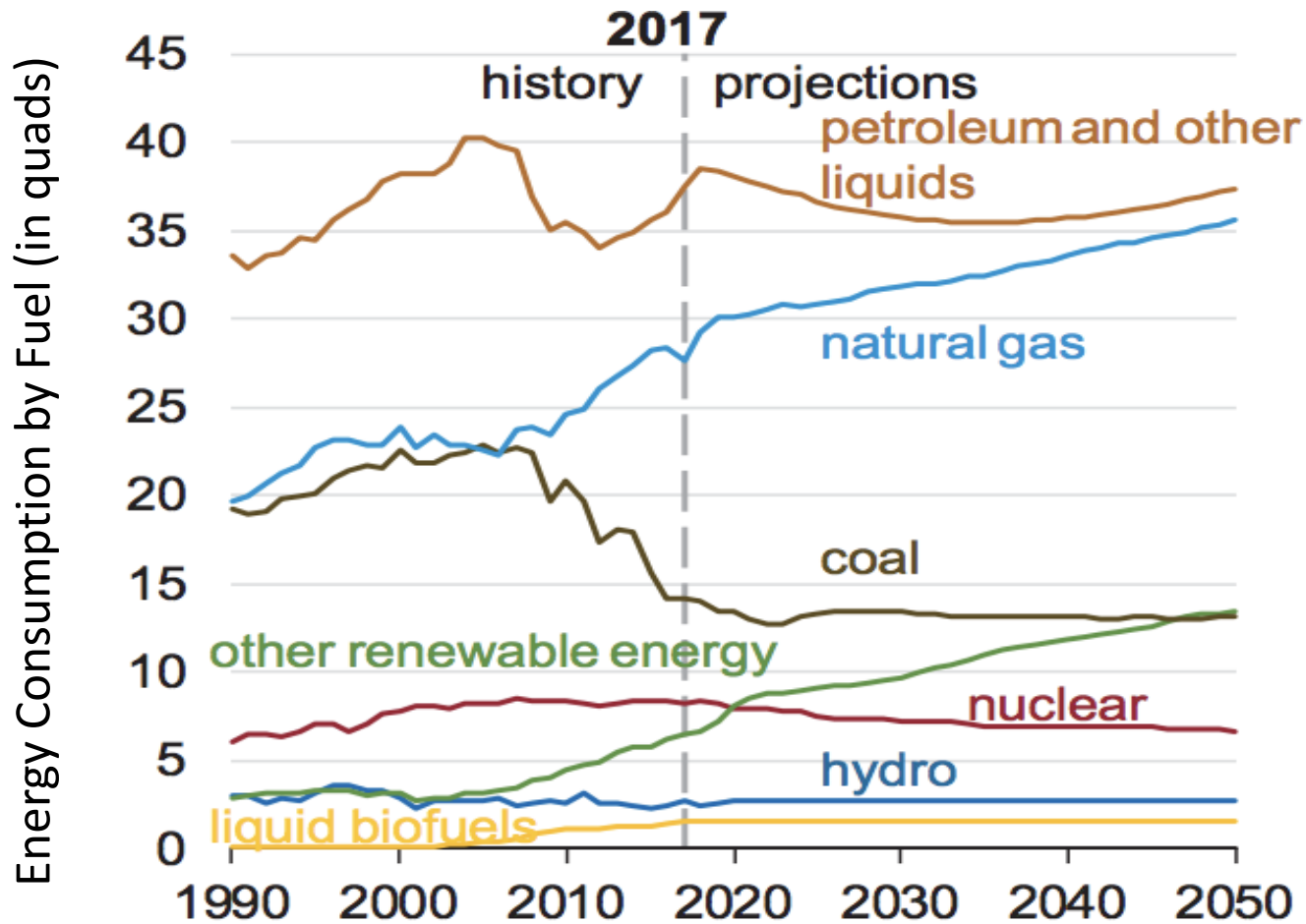
January 24, 2019
www.eia.gov/aio

U.S. Total Carbon Dioxide Emission from All Sectors



Sources: EIA, *Annual Energy Outlook 2019*. <https://www.eia.gov/outlooks/aeo/data/browser/#/?id=17-AEO2019&cases=ref2019&sourcekey=0>

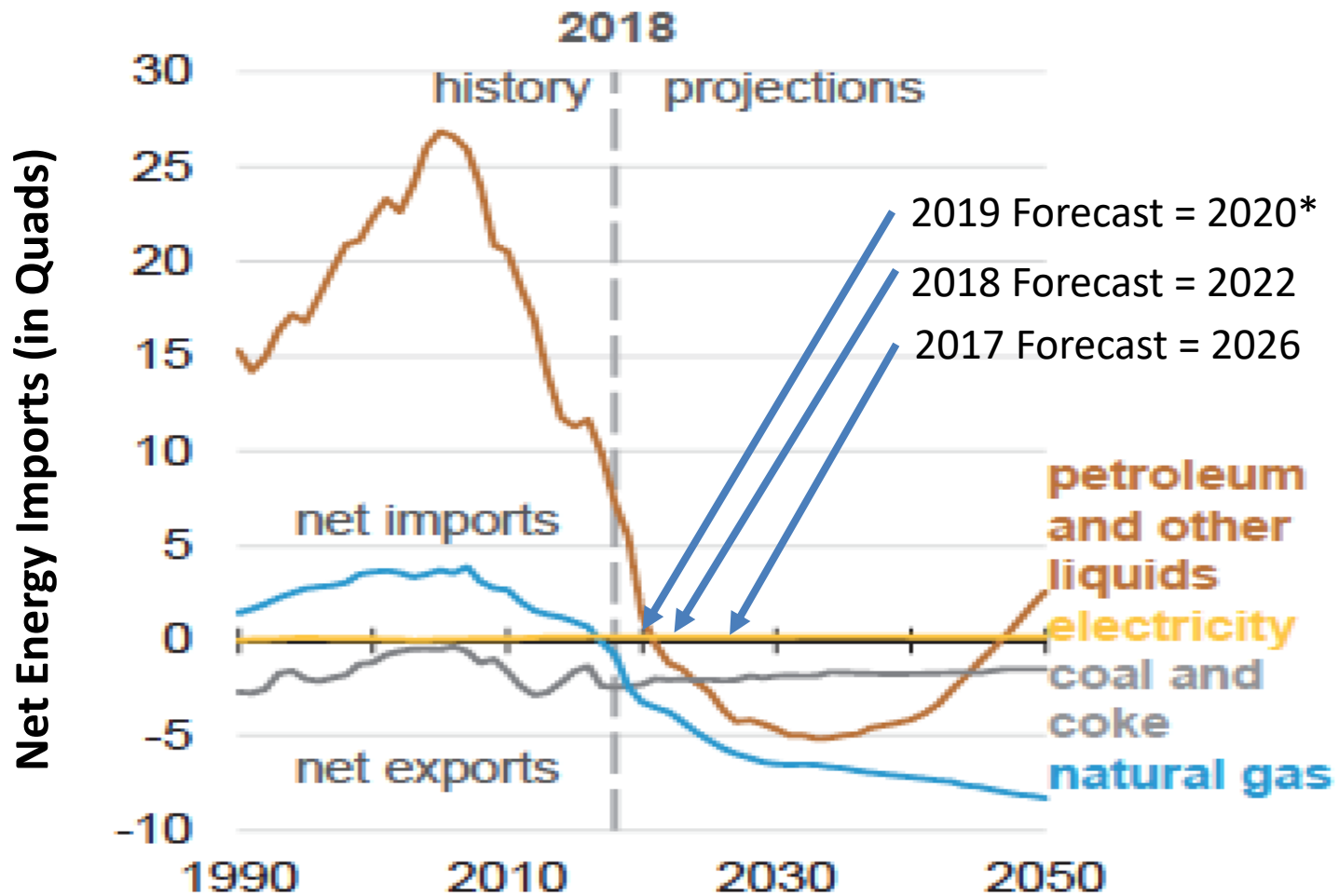
The U.S. Fuel Mix is Changing



Natural gas is expected to grow the most, but solar and wind are also on the rise.

Source: EIA, *Annual Energy Outlook 2018*

U.S. Will Soon be A Net Energy Exporter (First Time Since 1953)



Sources: EIA, *Annual Energy Outlook 2019**, 2018 and 2017

U.S. Liquefied Natural Gas (LNG) is Fueling Asia

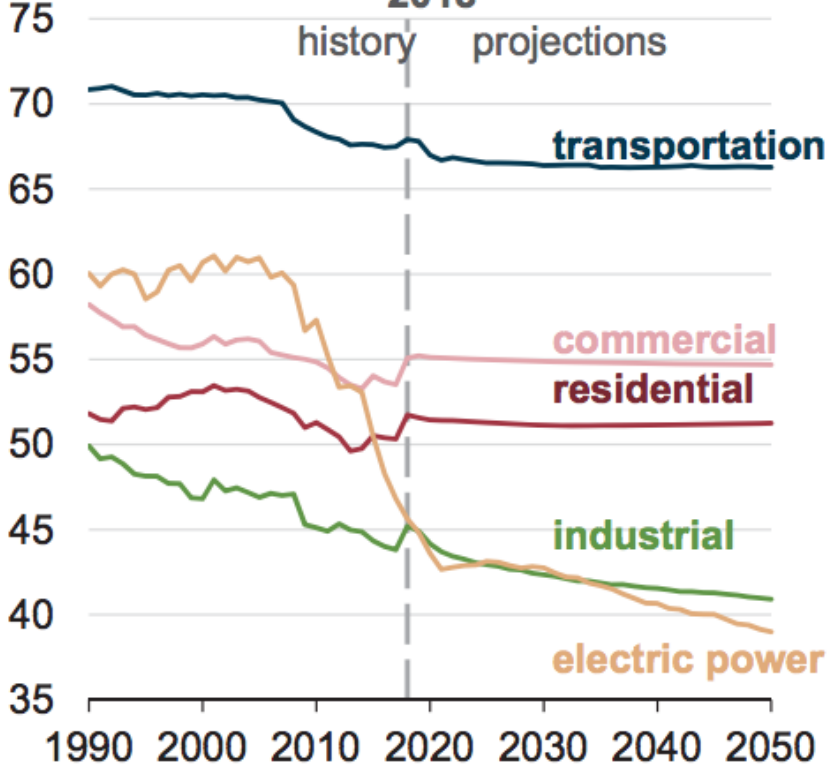


- U.S. natural gas trade was historically from Canada and to Mexico by pipeline.
- It is projected to become dominated by liquid natural gas (LNG) exports by tankers to distant ports.
- Hydrogen from natural gas reforming could be accommodated in this scenario as a bridge to the future.

Across the Globe and in the U.S.: The Power Sector is Leading the Way Towards Decarbonized Energy

Carbon dioxide intensity by end-use sector (Reference case)

metric tons of carbon dioxide per billion British thermal units



CO₂ intensity is declining
... especially in the
electric power sector

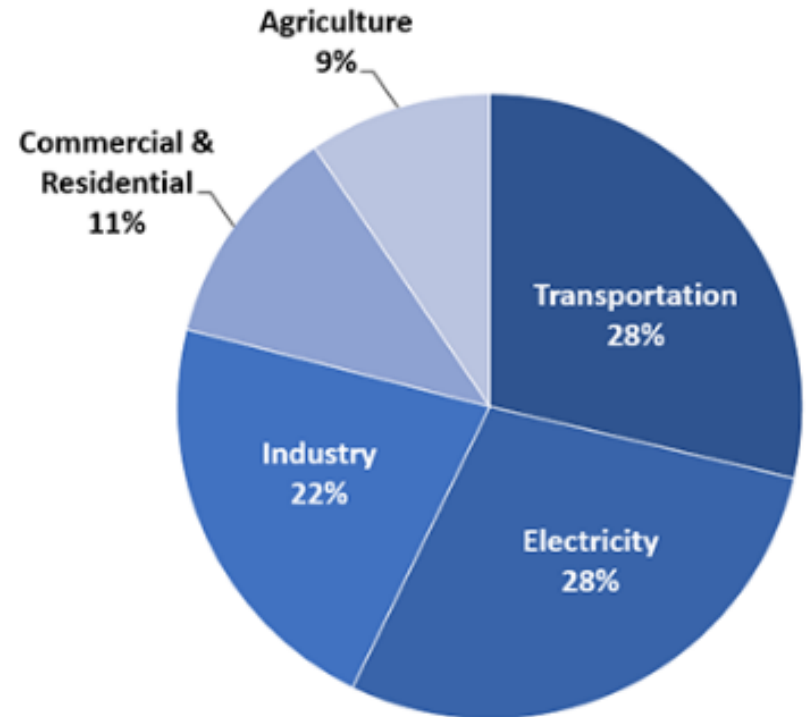
Sources: EIA, *Annual Energy Outlook 2019*

Electricity Systems Offer Low-Cost CO₂ Reductions

“Abatement” costs in electricity generation are consistently shown to be cheaper and easier than in:

- most end use (housing, transport) or
- intermediate sectors (industry, freight, agriculture)

Total U.S. Greenhouse Gas Emissions by Economic Sector in 2016



The Power of Consumers

Smart meters provide two-way communication:

- ✓ Powerful when combined with real-time electricity pricing
- ✓ WiFi enabled; controlled from computers & cell phones
- ✓ Interfaced with in-home, in-office, and smart phone displays

Sensors for temperature, humidity, motion, and light eliminate wasted energy (and improve comfort).

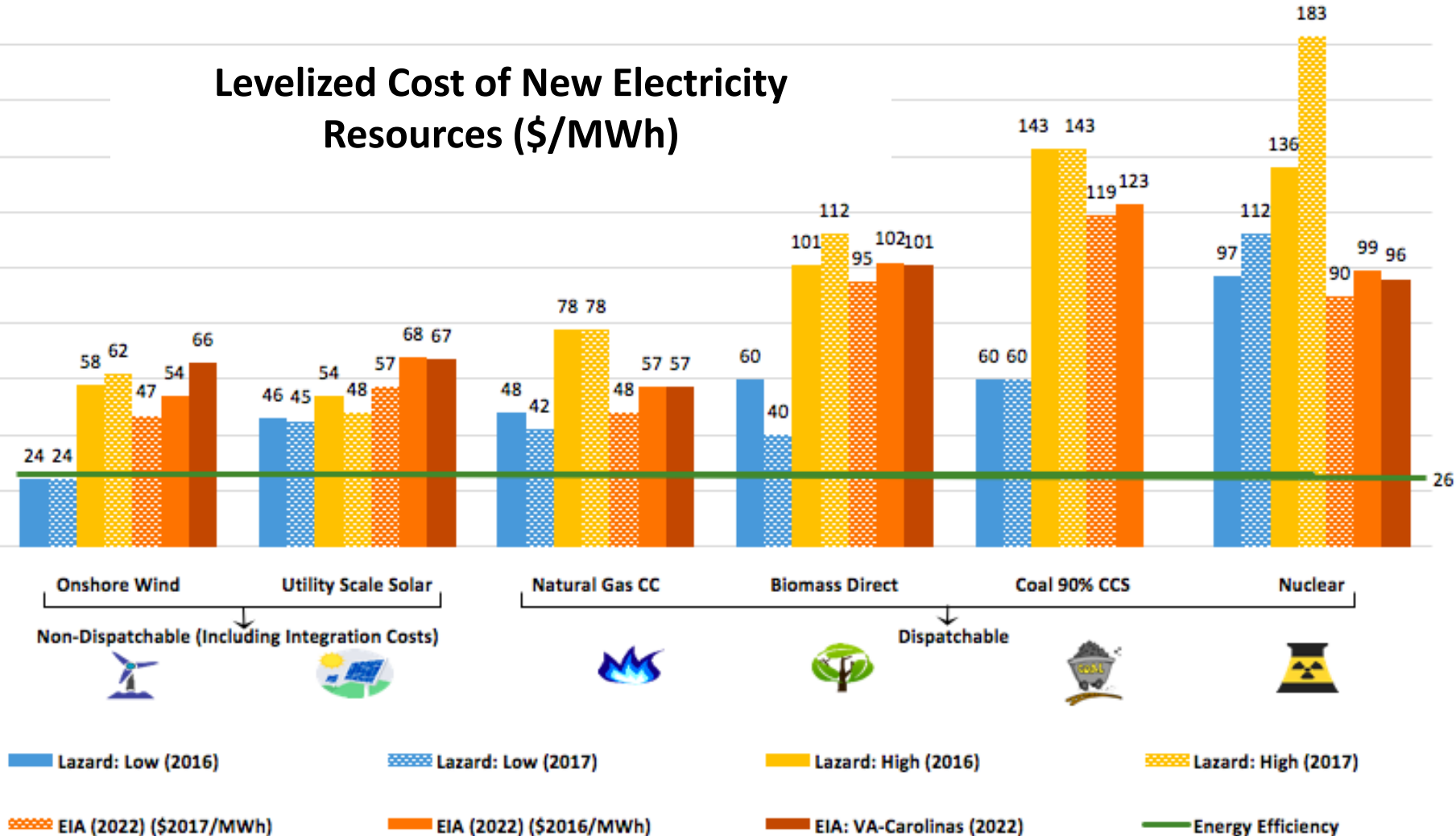


Thermostats that Learn



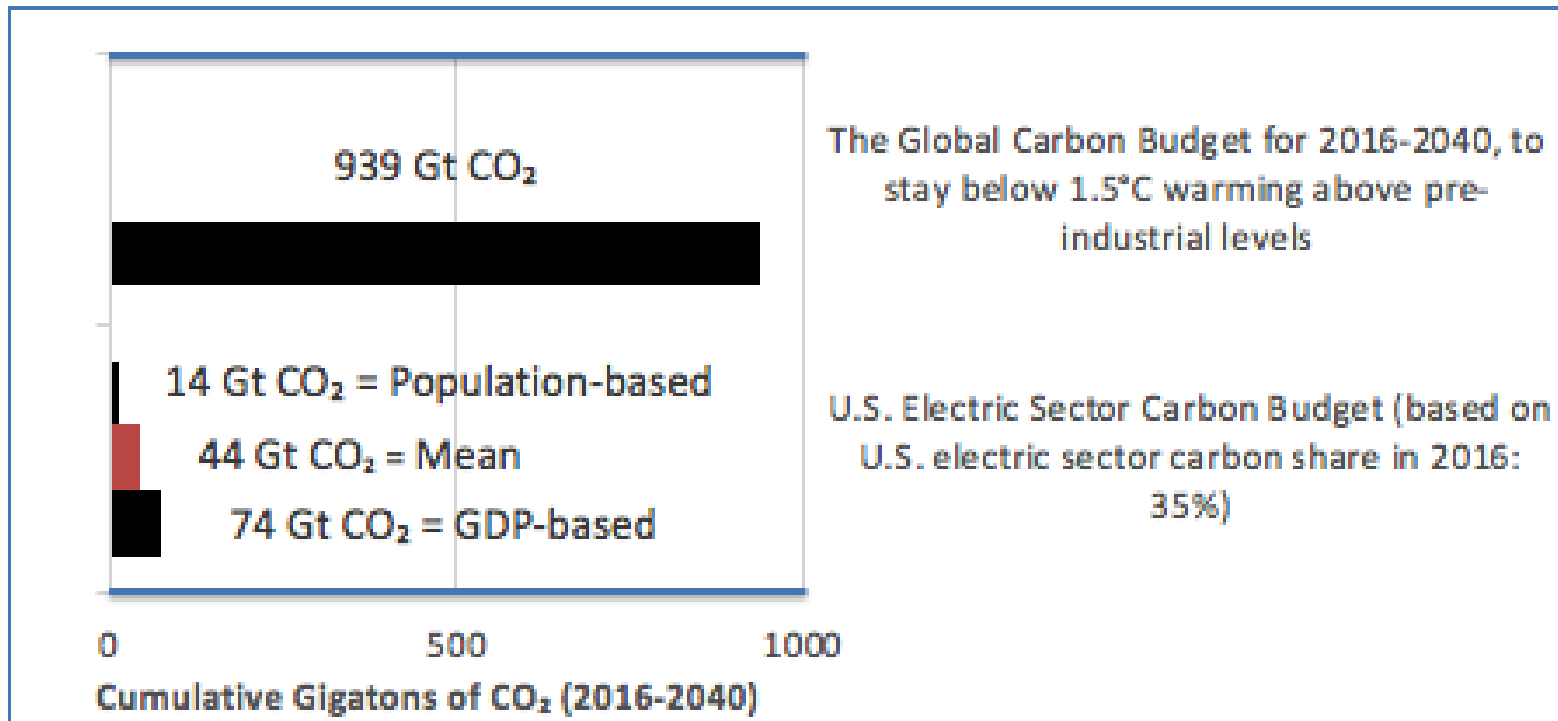
Energy Efficiency is the Least Cost Energy Resource in the U.S.

Levelized Cost of New Electricity Resources (\$/MWh)



What is 1.5°C Budget for the U.S. Electricity Sector?

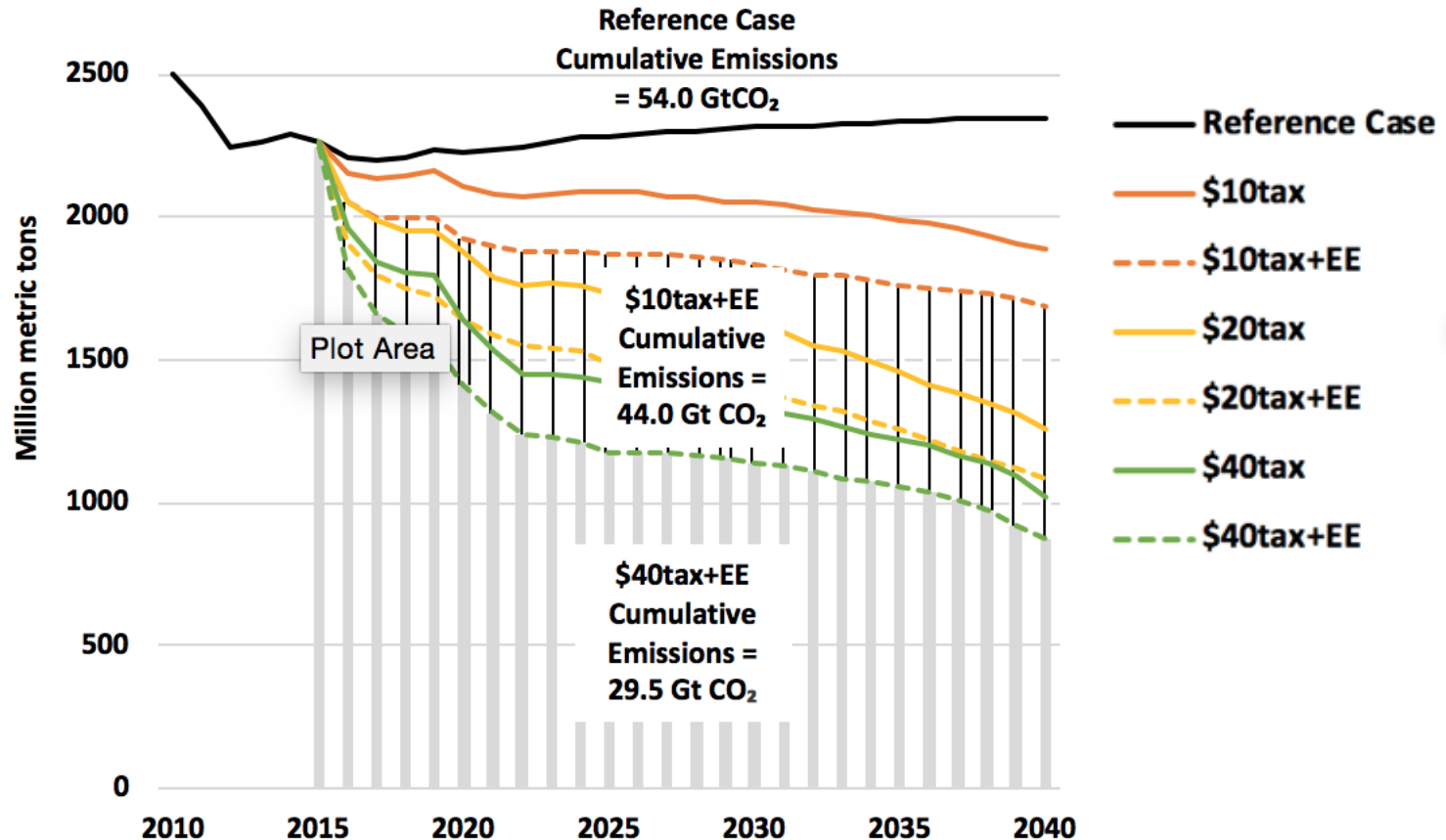
Equally weighting global “equity” and “inertia”, a 25-year carbon budget for the U.S. electric sector = **44 Gt CO₂**.



Source: Brown, Marilyn A. and Yufei Li. 2018. “Carbon Pricing and Energy Efficiency: Pathways to Deep Decarbonization of the U.S. Electric Sector,” *Energy Efficiency* 1-19, <https://doi.org/10.1007/s12053-018-9686-9>.

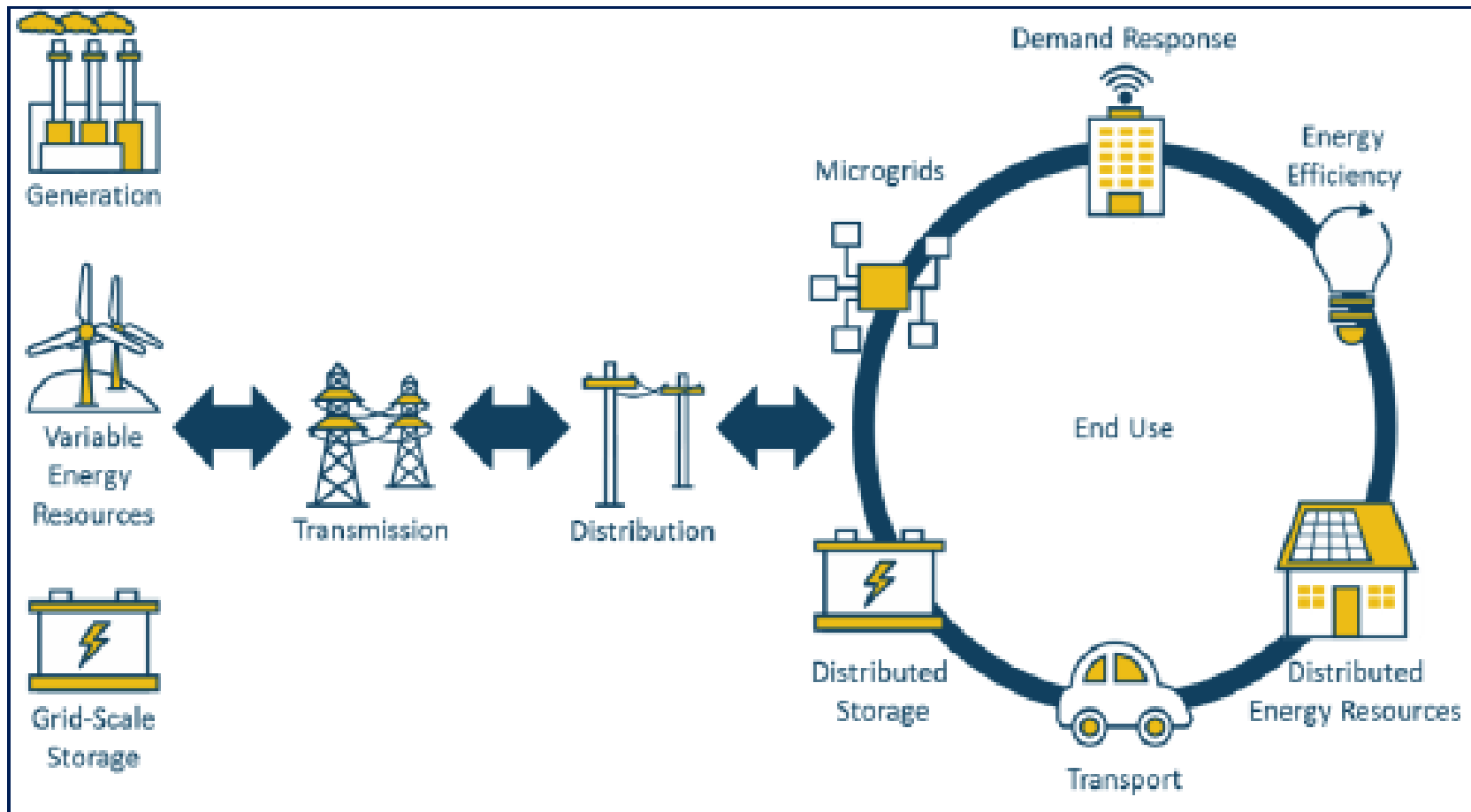
Results: CO₂ Emissions from the U.S. Electric Sector Across Mitigation Scenarios

Current policies would lead to 54 GT CO₂ in the U.S. electric sector from 2016-2040



A \$10 tax/ton of CO₂ with strong energy efficiency could reduce this to 44 GT CO₂.

The Energy Ecosystem is Transforming: Hydrogen Fuel Cells Could Fit In



Source: DOE. 2017. Quadrennial Energy Review: Transforming the Nation's Electricity System, Figure S-3

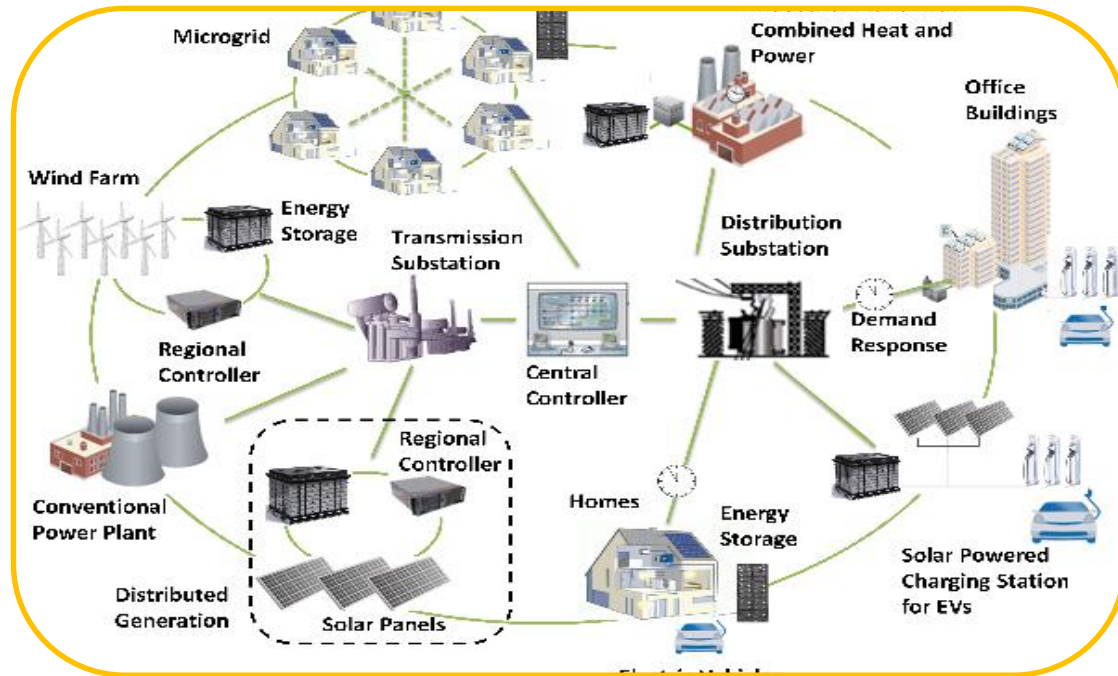
The Shift to Distributed Resources is Happening

- Distributed solar capacity is now nearly 1% of total U.S. generating capacity (14 GW).
- >14 million electric customers are supplying power back into the grid.
- >16 million customers participate in wholesale or utility demand response or time-varying rate programs.
- >80 GW of combined heat and power now accounts for ~8% of total U.S. generating capacity.
- The charging cycles of 535,000 EVs are now being managed.

Transportation & Electricity: A Beneficial Merger

More renewable
electricity + more
electric vehicles:
“complementary”
trends:

- ✓ With renewables,
EVs are even cleaner
- ✓ With EVs, the grid
can be better
balanced



Brown, Marilyn A., Shan Zhou, and Majid Ahmadi. 2018. "Governance of the Smart Grid: An international review of evolving policy issues and innovations," *Wiley Interdisciplinary Reviews (WIREs): Energy and Environment*.

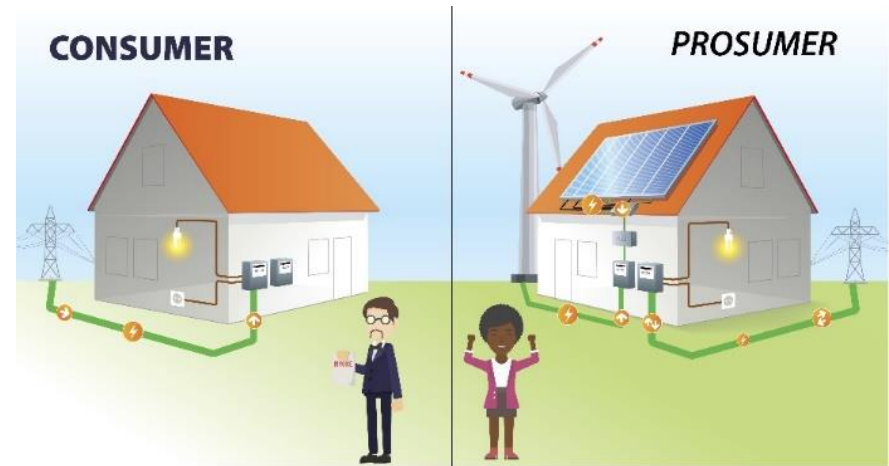
Visions of the Future

- Pairing storage with rooftop solar and EVs looks promising.
- The technologies are known, but the business models are unclear.



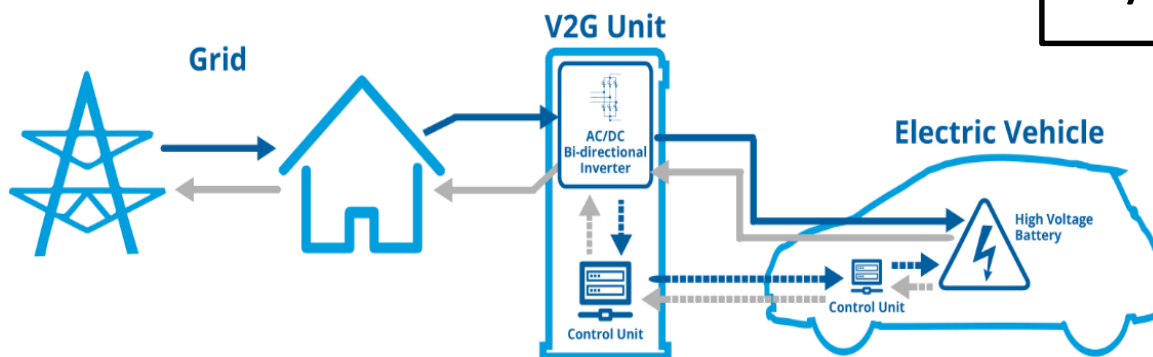
How Will HFCs Relate to “Prosumers” and the “Sharing Economy”?

- Consumers are becoming producers + consumers (“Prosumers”)



Grid-integrated vehicles could become another form of “prosumerism”

Open for smart business in your own garage?



Cities are First Responders, For both Mitigation and Adaptation



Source: NASA Goddard Space Flight Center, Conceptual Image Lab



Established June 2016

"The largest global coalition of cities committed to climate leadership, building on the commitments of more than **7,100** cities from **119** countries and six continents, representing more than **600** million inhabitants, over **8%** of the world's population"

~600 Compact cities commit to reducing GHG emissions by nearly 1 billion tons annually by 2030, or 11.6 billion tons between 2010 and 2030.

~6,000 cities of the EU Covenant of Mayors projected to have an estimated reduction of 240 Megatons of CO₂e, a reduction of 27% by 2020.

“Our Energy Destiny Lies with our Governments”—Fatih Birol, IEA

- “70% of all energy investments are government driven” ... What are feasible policies?
- We need affordable supplies of energy while transitioning to a low-carbon future ... where will the capital come from?
- Who will be the winners and losers of a clean energy transition?
- A deep understanding of consumers, markets and policies is needed – a socio-economic technical perspective.

Gigaton Problems Need Gigaton Solutions¹

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Achieving sustainability requires commanding the whole problem, not just iterative efforts that barely strike a moving target.



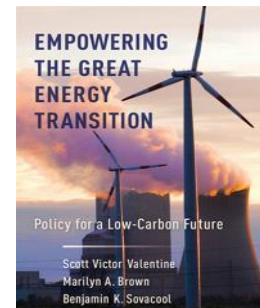
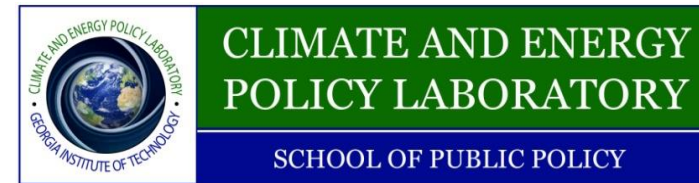
For More Information — and some late night reading??

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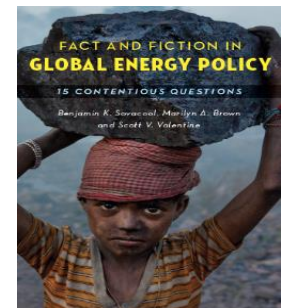
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Climate and Energy Policy Lab:

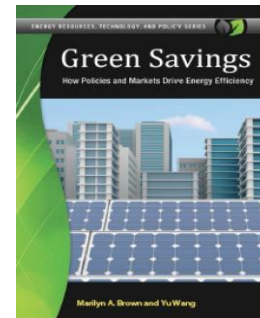
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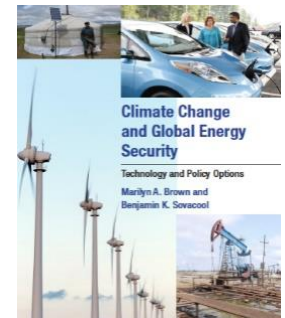
2019



2016



2015



2013



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